EXHIBIT G

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

AUTONOMOUS DEVICES LLC, Plaintiff, vs. TESLA, INC., Defendant.	Civil Action No._____ JURY TRIAL DEMANDED

<u>DECLARATION OF ELI SABER, PH.D.</u>

I, Eli Saber, Ph.D., hereby declare the following:

I. INTRODUCTION

1. Autonomous Devices retained me to offer technical opinions relating to U.S. Patent Nos. 10,452,974 ("the '974 Patent"); 11,238,344 ("the '344 Patent"); 10,607,134 ("the '134 Patent"); 11,113,585 ("the '585 Patent"); 11,055,583 ("the '583 Patent"); and 10,102,449 ("the '449 Patent") (collectively, the "Asserted Patents").

2. I am being compensated for my work on this matter by Autonomous Devices. My compensation is not dependent on the contents of this Declaration, the substance of any further opinions I may offer, or the outcome of this matter.

3. I have been asked to give my opinion on what the Asserted Patents are directed to and whether they are novel over the prior art. As explained in detail below, it is my opinion that the claims of each of the Asserted Patents are directed to resolving specific issues in artificial intelligence (AI), autonomous driving, and/or simulation technology and that each recites a sufficient "inventive concept" such that is novel over the prior art.

4. I reserve whatever right I may have to supplement this Declaration if further information becomes available or if I am asked to consider additional information. Furthermore, I reserve whatever right I may have to consider and comment on any additional expert statement and testimony of the Defendants' experts in this matter.

II. QUALIFICATIONS

5. My curriculum vitae, including my qualifications and a list of publications I have authored, is attached to this Declaration as Appendix A.

6. I received a Ph.D. in Electrical Engineering from the University of Rochester in 1996. My concentration was on Signal/Image/Video Processing, Pattern Recognition, and Computer Vision. I received a Master's Degree in Electrical Engineering from the University of

Rochester in 1992, and I received a Bachelor's Degree in Electrical and Computer Engineering, Summa Cum Laude, from the State University of New York at Buffalo in 1998.

7. I am a professor in the Electrical and Microelectronic Engineering Department and the Chester F. Carlson Center for Imaging Science at the Rochester Institute of Technology (RIT) in Rochester, New York. I also serve as the Director of the Image, Video and Computer Vision Laboratory. I joined RIT's full-time faculty in 2004. I have 34 years of industry and academic experience, 30 of which are in the field of imaging.

8. Before becoming a full-time professor, I worked for Xerox Corporation for 16 years, from 1988 to 2004. During my years at Xerox, I was responsible for delivering color management, image processing innovations, architectures, and algorithms; xerographic sub-systems for a variety of color products; and control systems for toner production facilities. One of several roles I held at Xerox was Advanced Development Scientist and Manager. In that capacity, I established the Advanced Design Laboratory – an Imaging/Xerographics lab – and provided technical and managerial leadership for the Electrical, Imaging and Xerographics Department. In another role, as Product Development Scientist and Manager, I led the research and development of image quality metrics for various product platforms. I also led the Image Science, Analysis, and Evaluation area, with 12 to 15 direct reports and a budget of approximately $2 million.

9. From 1997 until 2004, I was an adjunct faculty member in the Electrical Engineering Department of RIT and in the Electrical and Computer Engineering Department of the University of Rochester. I was responsible for teaching undergraduate and graduate coursework in signal, image and video processing; pattern recognition; and communications.

Additionally, I performed research in multimedia applications, computer vision, pattern recognition, image understanding and color engineering.

10. Since joining RIT full-time in 2004, I have been responsible for teaching a variety of undergraduate and graduate courses in digital signal processing, digital image processing, digital video processing (a course that I have founded and pioneered at RIT), engineering analysis, random signal and noise, advanced engineering mathematics, matrix methods, pattern recognition (a course that I founded and pioneered at RIT), communications, modern control theory, and linear systems.

11. My current research focuses on developing image/video processing and computer vision algorithms for multimedia and military applications. To this end, I have extensive experience in developing digital image/video processing and computer vision algorithms and techniques for motion estimation, segmentation, registration, classification, identification, pattern recognition, facial recognition, biomedical image processing, compression, surveillance systems, multiple camera systems, machine learning, deep learning and artificial intelligence and the fusion of techniques for a variety of applications including object recognition and tracking, video analysis, video surveillance, change detection, biomedical, color engineering, and document processing using multimodal/multispectral type imagery.

12. As a principal investigator or co-principal investigator, I have acquired research funding in excess of $5 million since joining RIT and have managed multiple government grants from the Department of Defense as well as several corporate grants from Hewlett-Packard, Lenel, and Data Physics. I am currently managing, as principal investigator, one government grant from the Department of Defense for "Target Detection/Tracking and Activity Recognition from Multimodal data". The work involves the development of machine learning/deep

learning/artificial intelligence type algorithms for fusion of multiple modalities using convolutional neural networks (CNN) to detect and tract small/sparse targets in aerial imagery.

13. In 2012, I was awarded the Prestigious Trustees Scholarship, the highest award at RIT with regard to research recognition

14. I am a senior member of the Institute of Electrical and Electronic Engineers and a member of the IEEE Signal Processing Society, the Electrical Engineering Honor Society, and Eta Kappa Nu.

15. I am the author or co-author of 38 peer-reviewed journal publications.

16. I have also authored or co-authored 100 conference and workshop publications and a book entitled Advanced Linear Algebra for Engineers with MATLAB, published by CRC Press in February 2009, and am a named inventor on multiple U.S. and foreign patents.

III. PERSON OF ORDINARY SKILL IN THE ART

17. In my opinion, a person of ordinary skill in the art ("POSITA") in the field of the Asserted Patents would have at least: (1) a bachelor's degree in electrical and/or computer engineering, or computer science (or equivalent course work) with two to three years of work experience in computer vision, image/video processing and the design and development of neural networks; or (2) a master's degree in electrical and/or computer engineering, or computer science (or equivalent course work) with a focus in computer vision, image/video processing and the design and development of neural networks. The POSITA would have gained this knowledge through a combination of education and work experience, for example, a master's degree in a relevant engineering field, such as electrical or computer engineering or computer science, and at least three years of work experience in that field. More education can substitute for less work experience, and more work experience can substitute for less education.

IV. MATERIALS CONSIDERED

18. I have reviewed the Asserted Patents, the prosecution history of each Asserted Patent, and other materials referenced in Appendix B to this Declaration. Counsel has informed me that I should consider these materials through the lens of a POSITA at the time of the priority dates of the patents, and I have done so. For the '974 patent and the '344 patent, I have assumed the priority date is November 2, 2006. For the '134 patent, I have assumed the priority date is December 19, 2016. For the '585 patent, I have assumed the priority date is August 23, 2016. For the '583 patent, I have assumed the priority date is November 26, 2017. For the '449 patent patent, I have assumed the priority date is November 21, 2017.

19. My analyses are based on my education and work experience and my investigation and study of materials listed in Appendix B.

V. APPLICABLE LEGAL PRINCIPLES

20. Although I am not an attorney, my understanding of the relevant law is as follows. I have been informed that a federal statute, 35 U.S.C. § 101, describes the types of inventions that are patentable. I have been further informed that the Supreme Court has held that this provision contains an important explicit exception: Laws of nature, natural phenomena, and abstract ideas are not patentable.

21. In its 2014 decision in *Alice Corp. v. CLS Bank Int'l*, I understand that the Supreme Court outlined a two-step test to determine whether a patent is ineligible under § 101 because it is directed to an abstract idea. 573 U.S. 208 (2014).

22. I have been informed that in the first step, the court determines whether the claims at issue are directed to a patent-ineligible concept, such as an abstract idea. I understand that federal courts have identified several factors to help determine whether an invention is directed to an abstract idea in the context of computer-related inventions.

23. I have been informed, for example, that courts examine whether a claim is directed to specific asserted improvements in computer capabilities or whether a claim is instead directed to a process that qualifies as an abstract idea for which computers are invoked as a tool. I understand that in the former case, the patent would not be directed to an abstract idea but in the latter case, it would.

24. I understand that courts have also phrased the step one inquiry to ask whether the claims merely implement an old practice in a new environment.

25. I have been informed that if the court determines the claims at issue are directed to an abstract idea, the court proceeds to a second step, asking what is in the claims before it. I am informed that in step two the court examines the elements of the claim to determine whether it contains an inventive concept sufficient to transform the claim abstract idea into a patent eligible application. I am informed that a court determines whether the claim elements individually, or as an ordered combination, contain an inventive concept which is more than merely implementing an abstract idea using well-understood, routine and conventional activities previously known in the industry. I understand that this step is often described as a search for an "inventive concept"—*i.e.*, an element or combination of elements sufficient to ensure that the patent in practice amounts to significantly more than a patent upon the ineligible concept.

26. I understand that whether a claim recites patent-eligible subject matter is a question of law that may contain underlying facts.

27. I understand that federal courts have said that whether a claim element or combination of elements is well-understood, routine, and conventional to a skilled artisan in the relevant field is a question of fact.

VI. OPINIONS

28. Since well before the priority dates of the Asserted Patents, the pursuit of autonomous driving has been extremely important. In fact, achieving a driverless vehicle has been described as the holy grail of the automotive industry.[1] Companies, such as Tesla, have spent an enormous sum of money in the pursuit of autonomous vehicles. Based on my experience in computer vision, machine learning, and computer assisted machine operations, achieving autonomous driving has been a significant problem due in large part to the complexity of the "driving" environment and the near-infinite number of circumstances encountered by such a vehicle.

29. Part of the difficulty was that prior art driver assistance aids were coded into the system, e.g., keep a certain distance from the lead vehicle,[2] maintain the vehicle between the lines on the road,[3] etc. Coding responses to circumstances was not sufficiently precise to enable autonomous device operation across the vast array of circumstances a vehicle may come across on a daily basis. And known "techniques lack[ed] a way to ***learn*** [the] operation of a device" and share that learned operation with another device to enable its autonomous operation. '974 patent at 1:26-35.

30. For example, the Notice of Allowance for the '974 patent stated that "the prior art does not disclose [a] device that operates as the user directs it, hence, does not disclose ***learning the device operation from the user directing the device***." '974 patent Notice of Allowance at 14; *see also* '344 patent Notice of Allowance at 12 (reciting similar reasons). The Notice of Allowance highlighted a robot patent (U.S. 2016/0167226) and its failure to disclose user

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[1] https://www.bloomberg.com/news/articles/2021-11-18/apple-accelerates-work-on-car-aims-for-fully-autonomous-vehicle
[2] http://sunnyday.mit.edu/safety-club/workshop5/Adaptive_Cruise_Control_Sys_Overview.pdf
[3] https://www.nissan-global.com/EN/INNOVATION/TECHNOLOGY/ARCHIVE/LDW/

assisted learning together with the remaining claimed features. That robot constructs a map of its environment using V-SLAM (Visual Simultaneous Location and Mapping). U.S. 2016/0167226 at ¶99. Using V-SLAM, the robot can "track its location and establish ground truth information with respect to captured images and/or image portions corresponding to views of specific map locations." *Id.* But there is no learning based on user operation and no sharing of learned responses to circumstances with other devices. *See, e.g.*, '974 patent at 1:26-35 ("[c]ommonly employed device or system operating techniques lack[ed] a way to ***learn [the] operation of a device***" to "enable autonomous operation" of that device and/or another device); '449 Patent at 1:20-23 (known "devices or systems [were] limited to relying on the user to direct them."); '583 Patent at 1:31-39 ("These systems and/or devices depend on user's input to various degrees for their operation. A machine learning solution [was] needed for computing enabled systems and/or devices to be less dependent on or fully independent from user input.").

31. The Notice of Allowance further explained that the "[p]rior art discloses a system that explores its own environment on its own, which is very different from relying on the user to direct it." '974 Notice of Allowance at 14; *see also* '344 patent Notice of Allowance at 12 (reciting similar reasons). And the "[p]rior art does not disclose the first and the second correlations that each include a circumstance representation correlated with instruction sets." '974 patent Notice of Allowance at 14; *see also* '344 patent Notice of Allowance at 12 (reciting similar reasons). Thus, the "[p]rior art does not disclose the knowledgebase," which includes a "circumstance representation (a data structure itself)," an "instruction set (a data structure itself when learned in the learning process)" or a "correlation (a data structure itself) that includes a circumstance representation correlated with instruction sets." '974 patent Notice of Allowance at 14-15; *see also* '344 patent Notice of Allowance at 12 (reciting similar reasons).

32. Similarly, in allowing the ’583 patent, the USPTO explained that the prior art fails to disclose learning the correlation between an image and an instruction set—rather the prior art “only adds [an] unidentified object to the database by a manual or formal approval process” and there is no suggestion of “learning a correlation between the image and any instruction set(s) for operating a device.” ’583 patent Notice of Allowance at 12-13.

33. Notably, early prior art systems attempted to achieve vehicle self-driving by training the system using synthetic road images, which resulted in poor performance in real driving situations. *See* Pomerleau, D.A. (1991) Efficient Training of Artificial Neural Networks for Autonomous Navigation in Neural Computation, pp. 88-97 at 4. To overcome these problems, the next generation prior art systems tried to imitate a person’s driving under actual driving conditions. *Id.* at 5. However, those systems suffered from flaws due to overlearning from repetitive inputs. *Id.* For example, if the driver goes down a straight stretch of road during part of a training run, the network was presented with a long sequence of similar images. *Id.* This sustained lack of diversity in the training caused the network to “forget” what it had learned about driving on curved roads and instead learn to, generally speaking, steer straight ahead. *Id.*

34. More recent prior art suggests that carmakers have resorted to more predictable and less robust solutions. For example, known lane-keeping assist (“LKA”) systems detect lane markers (white/yellow) on the road and assist the driver in keeping the vehicle between lane markers.[4] Another example of a known driver assistance feature is adaptive cruise control (“ACC”). Adaptive cruise control measures the distance from the vehicle ahead and controls the acceleration and deceleration of the vehicle at hand to automatically maintain a suitable

[4] https://www.nissan-global.com/EN/INNOVATION/TECHNOLOGY/ARCHIVE/LDW/

following distance.[5] These systems, however, simply executed pre-coded responses to a limited number of circumstances.

35. As a result, there has long been a demand for solutions that can account for the broad array of scenarios encountered by an autonomously operating device. The innovations in the Asserted Patents, as discussed below, permit devices to operate autonomously at least based on learned experiences from other devices. These innovations are novel and inventive. Said another way, the prior art systems lacked the ability to *learn from a driver's response to a circumstance and share learned responses across a fleet of vehicles so that those vehicles can respond autonomously to a similar situation*.

36. The prior art's limited capabilities are not surprising. Generally speaking, the art had moved away from early attempts at neural network-based algorithms and towards coded responses to limited situations in order to enable solutions such as LKA and/or ACC. The reasons for this transition are numerous. To this effect, early attempts at using neural network-based solutions for self-driving were known to have problems with overlearning from their most recent experience(s). Moreover, complex environments, such as busy city streets or highways, offer many dynamic changes and challenges that need to be resolved in real or near real time in order to render proper actions. Hence, a neural network-based solution would have required a high-degree of complexity with many potential nodes/layers to accurately and effectively manage the challenges and dynamics of the environment; and ample computational power to compute solutions/render actions in real or near real time. However, until recently, the computation engines required to host the neural network-based solutions were not up to par to handle the complexity and dynamics of the underlying environment. With the

[5] http://sunnyday.mit.edu/safety-club/workshop5/Adaptive_Cruise_Control_Sys_Overview.pdf

introduction/arrival of more powerful processors and multitasking capabilities, many new doors were opened, such as those that led to the innovations in the Asserted Patents.

37. Given the difficulties with early neural network applications and the limitations with pre-coded solutions, it was not known or obvious to use a fleet of vehicles to train one another to react autonomously to a diverse set of situations.

A. THE OBJECT REPRESENTATION PATENTS (US Patent Nos. 10,452,974 & 11,238,344)

38. The Object Representation Patents are generally directed to a system, method and computer readable medium. By way of example, the system stores a knowledgebase that correlates device operating instruction sets with circumstances encountered by a device, obtains a new circumstance representation using device sensors, matches the new circumstance with a circumstance in an a priori maintained knowledgebase, and causes the device that detected the new circumstance to autonomously execute an instruction set correlated to the matched circumstance. The autonomously performed operation is based on a correlation previously acquired in a learning process that includes operating, at least partially by a user, the device that captured the instruction and the stored circumstance.

39. For example, if a second autonomous vehicle detects a circumstance representation (e.g., one or more object representations such as debris or people in the road) and the knowledgebase has a similar circumstance representation that matches with the detected circumstance, then the second autonomous vehicle performs an instruction set (e.g., braking) at least partially learned by operating a first autonomous vehicle that captured the similar circumstance representation.

40. Referring to Figure 38, for example, vehicle 98 includes sensors 92, such as a camera 92a that detect objects 615aa-ad (people, boulders, materials, vehicles, etc.) in the

vehicle's 98a's surrounding in the form of a circumstance representation.[6] '344 Patent[7] at 162:48-163:16; Fig. 38. If the vehicle's computer(s) detect a match (or partial match) with a previously learned circumstance representation 525 (e.g., one or more object representations), the vehicle 98 performs autonomous operation using previously learned instructions 526 correlated with the previously learned circumstance representation. *Id.* at 163:36-164:5.

41. In my opinion, the corresponding claimed features were not well-understood, routine or conventional as of the priority date of the Object Representation Patents. For instance, the memory of the device performing the autonomous operation stores a knowledgebase that correlates instructions for performing the operation with the stored circumstance representation.[8] The device performing the autonomous operation also obtains a circumstance representation while in operation, e.g., it captures circumstances surrounding a vehicle using its camera, for example.[9] When there is at least a partial match between the stored circumstance representation and the current circumstance representation, the corresponding instruction is autonomously

[6] Figure citations include the specification discussion of each figure.

[7] The Object Representation Patents share a specification. For simplicity, duplicative citations are not always provided.

[8] *See e.g.*, '974 patent at cl. 1 ("a memory that stores at least a knowledgebase that includes: a first correlation including a first circumstance representation correlated with a first one or more instruction sets …"), cl. 18 ("accessing a memory that stores at least a knowledgebase that includes: a first correlation including a first circumstance representation correlated with a first one or more instruction sets for operating a first device"); '344 patent at cl. 1 ("a memory that stores at least a knowledgebase that includes a first circumstance representation correlated with a first one or more instruction sets for operating a first device…").

[9] *See e.g.*, '974 patent at cl. 1 ("the third circumstance representation represents a third circumstance detected … at least in part by one or more sensors of a second device"), cl. 18 ("the third circumstance representation represents a third circumstance detected … at least in part by one or more sensors of a second device"); '344 patent at cl. 1 ("the second circumstance representation represents a second circumstance detected at least in part by: … one or more sensors of a second device").

performed by the device that matched the current and stored circumstance representations.[10] The claim features linked to the above-described example are inventive and novel and, as of the priority date of the Object representation patents, were not well-understood, routine or conventional.

42. In some embodiments, the circumstance representations include one or more object representations, e.g., the circumstance representations included representations of object(s) such as debris, people, vehicles, etc.[11] The claim features linked to the above-described example are inventive and novel and, as of the priority date of the Object representation patents, were not well-understood, routine or conventional.

[10] *See e.g.*, '974 patent at cl. 1 ("anticipating the first one or more instruction sets for operating the first device learned in the learning process based on at least partial match between the third circumstance representation and the first circumstance representation; and at least in response to the anticipating, executing the first one or more instruction sets for operating the first device learned in the learning process, wherein … the second device autonomously performs one or more operations defined by the first one or more instruction sets for operating the first device learned in the learning process"), cl. 18 ("anticipating the first one or more instruction sets for operating the first device learned in the learning process based on at least partial match between the third circumstance representation and the first circumstance representation; and at least in response to the anticipating, causing … the second device to perform one or more operations defined by the first one or more instruction sets for operating the first device learned in the learning process at least by causing the one or more processor circuits or another one or more processor circuits to execute the first one or more instruction sets for operating the first device learned in the learning process."); '344 patent at cl. 1 ("anticipating the first one or more instruction sets for operating the first device based on at least partial match between the second circumstance representation and the first circumstance representation; and at least in response to the anticipating, executing the first one or more instruction sets for operating the first device, wherein … the second device autonomously performs one or more operations defined by the first one or more instruction sets for operating the first device.")

[11] *See, e.g.*, '344 patent at cl. 3 ("wherein the first circumstance representation includes a first one or more object representations, and wherein the second circumstance representation includes a second one or more object representations"); *see also* '974 patent at cl. 14 (" wherein the first circumstance representation includes: one or more object representations, or one or more collections of object representations, and wherein the second circumstance representation includes: one or more object representations, or one or more collections of object representations, and wherein the third circumstance representation includes: one or more object representations, or one or more collections of object representations.")

43. With the innovations in the Object Representation Patents, autonomous device operation using a knowledgebase (e.g., a neural network that includes, for example, a combination of circumstance/object recognition and correlated previously learned instructions) that is trained by a fleet of vehicles became possible.[12] *See, e.g.*, Ex. B ('344 Patent) at 164:6-28; *See also id.* at 15:36-45; 38:54-40:34; 82:6-14; 95:15-96:25; 103:35-105:22; 108:40-44. The corresponding claimed features are inventive and novel and were not well-understood, routine or conventional as of the priority date of the Object Representation Patents.

44. By utilizing the autonomous device operating techniques disclosed in the Object Representation Patents, a vehicle can perform autonomous operations based on previously learned circumstances and instructions. For at least the above-mentioned reasons, the claimed inventions improve the capabilities of autonomous devices that employ the systems and methods disclosed in the Object Representation Patents. Further, the inventions claimed in the Object Representation Patents cannot be performed as mental steps by a human, nor do they represent the application of a generic computer to any well-known method of organizing human behavior. The claims of the Object Representation Patents are also directed to non-abstract ideas in that they provide technical solutions to at least the technical problems described above with respect to coded responses, lack of training set diversity, and user operation corresponding to the correlated circumstances and instructions in the knowledgebase.

45. Claim 1 of each Object Representation Patent, as a whole, is inventive and novel, as are at least the herein identified claim limitations. *See, e.g.*,'974 Patent at Claim 1 ("accessing a memory that stores at least a knowledgebase that includes: a first correlation including a first

[12] *See e.g.*, '974 patent at cl. 1 (element starting with "at least in response to the anticipating, executing the first one or more instruction sets…"); '344 patent at cl. 1 (element starting with "at least in response to the anticipating, executing the first one or more instruction sets …")

circumstance representation correlated with a first one or more instruction sets for operating a first device", "a learning process that includes operating the first device at least partially by a user" and "the second device autonomously performs one or more operations defined by the first one or more instruction sets for operating the first device learned in the learning process"), claim 18 ("a learning process that includes operating the first device at least partially by a user" and "causing … the second device to perform one or more operations defined by the first one or more instruction sets for operating the first device learned in the learning process at least by causing the one or more processor circuits or another one or more processor circuits to execute the first one or more instruction sets for operating the first device learned in the learning process.");'344 Patent at Claim 1 ("accessing a memory that stores at least a knowledgebase that includes a first circumstance representation correlated with a first one or more instruction sets for operating a first device", "a learning process that includes operating the first device at least partially by a user" and "the second device autonomously performs one or more operations defined by the first one or more instruction sets for operating the first device"). As of the priority date of the '974 and '344 patents, the above-mentioned claim elements were not well-understood, routine, or conventional, and the novel user-trained knowledgebase that is capable of being deployed and utilized by other vehicles in the fleet is a vast improvement over the prior art.

46. Moreover, claim 3 of the '344 patent and claim 14 of the '974 patent, as a whole, are also inventive and novel, as are at least the herein identified claim limitations. *See, e.g.*, '344 patent at cl. 3 ("wherein the first circumstance representation includes a first one or more object representations, and wherein the second circumstance representation includes a second one or more object representations"); *see also* '974 patent at cl. 14 (" wherein the first circumstance representation includes: one or more object representations, or one or more collections of object

representations, and wherein the second circumstance representation includes: one or more object representations, or one or more collections of object representations, and wherein the third circumstance representation includes: one or more object representations, or one or more collections of object representations.") As of the priority date of the '974 and '344 patents, the above-mentioned claim elements were not well-understood, routine, or conventional, and the novel user-trained knowledgebase that is capable of being deployed and utilized by other vehicles in the fleet is a vast improvement over the prior art.

47. In my opinion, the above-mentioned claimed features unlocked the next level of autonomous driving because they allowed an entire fleet to train the system providing a higher degree to diversity in the training process. As a result, much more precise and appropriate reactions to driving circumstances became possible. This is because, using the claimed features, the massive number of scenarios encountered by the fleet could be distilled into a set of circumstances and corresponding instructions that can be efficiently performed autonomously by vehicles within the fleet. The corresponding claimed concepts were not known or done in the prior art.

48. The claims of the Object Representation Patents recite one or more inventive concepts rooted in computerized technology that overcome technical problems in that field. A person of ordinary skill in the art reading the Object Representation Patents and their claims would understand that the Object Representation Patents' disclosures and claims are drawn to solving specific technical problems arising in artificially intelligent and autonomous devices and systems. Accordingly, each claim of the Object Representation Patents recites a combination of elements sufficient to ensure that the claim in practice amounts to significantly more than a

patent claiming an abstract concept. Further, the claimed improvements over the prior art are concrete and improve the capabilities of existing autonomous and artificial intelligence systems.

49. A person of ordinary skill in the art reviewing the specification of the Object Representation Patents would understand that the inventor had possession of the claimed subject matter and would know how to practice the claimed invention without undue experimentation.

B. THE DIGITAL PICTURE PATENTS (U.S. PATENT NOS. 10,102,449 & 11,055,583)

50. The '583 Patent is generally directed to systems, methods, and non-transitory machine-readable mediums for correlating an instruction set for operating a first device with digital pictures, obtaining a new digital picture, and in response to matching the new digital picture with a correlated digital picture, causing the device that obtained the new digital picture to perform operations defined by the instruction set correlated to the matched digital picture.[13] The instruction set for operating the first device may be executed by a second device in response to the second device matching the new picture with the picture correlated to the instruction sets.[14] As of the priority date of the '583 patent, the combination of the above-mentioned concepts corresponding to the claimed "learning," obtaining "a new one or more digital pictures," and "causing" a "second device to perform" an operation defined by the first instruction set(s) was not well-understood, routine or conventional.

51. Similarly, the '449 Patent is generally directed to a system, method and non-transitory computer readable medium that correlates an instruction set for operating a first device

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[13] *See, e.g.*, '583 patent at cl. 1 ("learning the first one or more digital pictures correlated with the first one or more instruction sets for operating the first device"); cl. 4 ("receiving or generating a new one or more digital pictures", "determining the first one or more instruction sets for operating the first device based on at least partial match between the new one or more digital pictures and the first one or more digital pictures", "causing … a second device to perform one or more operations defined by the first one or more instruction sets for operating the first device.")
[14] *Id.*

with a digital picture, provides an artificial intelligence (AI) unit that: (i) receives a new digital picture, (ii) matches the new digital picture with the digital picture correlated to the instruction set, and (iii) causes a device that received the new digital picture to execute the instruction set correlated to the matched digital picture.[15] As of the priority date of the '449 patent, the combination of the above-mentioned features corresponding to claim elements (a) to (e) was not well-understood, routine or conventional.

52. By way of example, consider a situation where a second autonomous vehicle receives a new digital picture of people in the road and where the knowledgebase has a similar digital picture that matches with the new digital picture. In this situation, using the above-discussed claimed inventions, the second autonomous vehicle performs an instruction set (e.g., braking) at least partially learned by operating a first autonomous vehicle. As of the priority date of the Digital Picture Patents, the execution of an instruction set on one vehicle where that

[15] *See, e.g.*, '449 patent at cl. 1 ("a memory that stores at least a first one or more digital pictures correlated with a first one or more instructions sets for operating a first physical device, … a learning process that includes operating the first physical device at least partially by a user", "an artificial intelligence unit that: receives a new one or more digital pictures from the optical camera; anticipates the first one or more instruction sets for operating the first physical device based on at least partial match between the new one or more digital pictures and the first one or more digital pictures, … causes the one or more processor circuits to execute the first one or more instruction sets for operating the first physical device, wherein the causes is performed in response to the anticipates of the artificial intelligence unit, and wherein … a second physical device autonomously performs one or more operations defined by the first one or more instruction sets for operating the first physical device."), cl. 17 ("(a) accessing a memory that stores at least a first one or more digital pictures correlated with a first one or more instructions sets for operating a first physical device, … wherein at least a portion of the first one or more digital pictures or at least a portion of the first one or more instruction sets for operating the first physical device are learned in a learning process that includes operating the first physical device at least partially by a user", "(b) receiving a new one or more digital pictures from an optical camera", "(c) anticipating the first one or more instruction sets for operating the first physical device based on at least partial match between the new one or more digital pictures and the first one or more digital pictures", "(d) executing the first one or more instruction sets for operating the first physical device," and "(e) autonomously performing, … a second physical device, one or more operations defined by the first one or more instructions [sets] for operating the first physical device.")

instruction set was learned on another vehicle was inventive and novel, and this feature was not well-understood, routine, or conventional.

53. Referring to Figure 38 of the ’449 patent, for example, the vehicle 98a includes sensors 90, such as a camera 90a that detect the vehicle’s surroundings in the form of a digital picture. ’449 Patent at 152:21-154-27, Figs. 37, 38; *see also* ’583 Patent at 152:33-154:39, Figs. 37-38. If the vehicle’s computer(s) detect a match with a previously learned digital picture 525, the vehicle 98 performs autonomous operation using previously learned instructions 526 correlated with the previously learned digital picture. *See, e.g.*, ’449 Patent at 154:5-27; *see also* ’583 Patent at 154:14-24. The algorithms correlate instructions for performing an operation with the stored digital picture and when there is a match or partial match with the digital picture the operation is performed. ’449 Patent at 154:5-27; *see also* ’583 Patent at 154:14-24. The corresponding claimed features, as a combination, are inventive and novel and were not well-understood, routine or conventional as of the priority date of the Digital Picture Patents.

54. The memory of the device performing the autonomous operation stores a correlation between instructions for performing an operation and a digital picture.[16] When there is at least a partial match between the stored digital picture and a new digital picture, the operation is autonomously performed by the device that matched the new and stored digital pictures.[17] The corresponding claimed features are novel and inventive and were not well-understood, routine or conventional as of the priority date of the Digital Picture Patents.

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[16] ’449 Patent at cl. 1 (element beginning with “a memory that stores...”), cl. 17 (element (a)); ’583 patent at claim 1 (element starting with “learning”); claim 4 (element starting with “determining”).

[17] ’449 patent at cl. 1 (elements beginning with “anticipates…” and “causes …”), cl. 17 (elements (c) to (e)); ’583 patent at claim 4 (element starting with “at least in response to”).

55. With the innovations in the Digital Picture Patents, autonomous device operation using a memory with instruction and picture correlations (e.g., a neural network that includes, for example, a combination of digital pictures and correlated previously learned instructions) that is trained by a fleet of vehicles became possible. *See, e.g.*,'449 Patent at 14:38-45 ("In certain embodiments, the autonomous device operating includes a partially or a fully autonomous device operating. The partially autonomous device operating may include executing the one or more instruction sets for operating the device correlated with the first digital picture responsive to a user confirmation. The fully autonomous device operating may include executing the one or more instruction sets for operating the device correlated with the first digital picture without a user confirmation."); *see also id.* at Figs. 31-35; '583 Patent at 14:54-62, Figs. 31-35. The corresponding claimed features were not well-understood, routine or conventional as of the priority date of the Digital Picture Patents. As of the priority dates of the Digital Picture Patents, the above-mentioned claim elements novel and a user-trained knowledgebase that is capable of being deployed and utilized by other vehicles in the fleet is a vast improvement over the prior art.

56. Thus, by utilizing the autonomous device operating techniques disclosed in the Digital Picture Patents, a vehicle can perform autonomous operations based on previously learned pictures and instructions. For at least the above-mentioned reasons, the claimed inventions improve the capabilities of autonomous devices that employ the systems and methods disclosed in the Digital Picture Patents. Further, the methods claimed in the Digital Picture Patents cannot be performed as mental steps by a human, nor do they represent the application of a generic computer to any well-known method of organizing human behavior. The claims of the Digital Picture Patents are also directed to non-abstract ideas in that they provide technical solutions to at least the technical problems described above with respect to coded responses, lack

of training set diversity, and user operation corresponding to the correlated pictures and instructions in the knowledgebase.

57. The claimed features unlocked the next level of autonomous driving by allowing the entire fleet to train the overall system. In this way, much more precise and appropriate reactions to driving circumstances became possible because the massive number of scenarios encountered by the fleet could be distilled into a set of digital pictures and corresponding instructions that could be efficiently performed autonomously in an effective manner.

58. The claims of the Digital Picture Patents recite one or more inventive concepts rooted in computerized technology that overcome technical problems in that field. A person of ordinary skill in the art reading the Digital Picture Patents and their claims would understand that the Digital Picture Patents' disclosures and claims are drawn to solving specific technical problems arising in artificially intelligent and autonomous devices and systems. Accordingly, each claim of the Digital Picture Patents recites a combination of elements sufficient to ensure that the claim in practice amounts to significantly more than a patent claiming an abstract concept. Further, the claimed improvements over the prior art are concrete and improve the capabilities of existing autonomous and AI systems.

59. A person of ordinary skill in the art reviewing the specification of the Digital Picture Patents would understand that the inventor had possession of the claimed subject matter and would know how to practice the claimed invention without undue experimentation.

C. THE SIMULATION PATENTS (U.S. PATENT NOS. 10,607,134 & 11,113,585)

60. Claim 1 of both the Simulation Patents recites a system for causing an avatar or an object of an application program to autonomously perform operations defined by instruction sets previously learned by that device or another device by anticipating the instruction set(s) to

be executed (e.g., apply brakes) in response to finding at least a partial match between a previously learned digital picture ('585 patent) or object representation ('134 patent) and a newly received picture or object representation (e.g., similar debris on the road). *See* '134 patent at claim 1; '585 patent at claim 1.

61. Based on my extensive experience in computer vision, image/video processing, machine learning, and computer assisted machine operations, achieving methods for full-self driving has been difficult due in large part to the near-infinite number of circumstances encountered by a vehicle and the high-degree of variability has been a significant problem. For example, the prior art avatar and object operation was "semi-autonomous." As explained by the Patent Examiner, the prior art of record does not teach the details of object representations, avatars, determining instruction sets, and causing an avatar to perform operations as recited in the claims. *See generally* '134 Patent Notice of Allowance at 16. The examiner then went on to characterize certain prior art as teaching semi-autonomous avatar operation and learning, but not teaching how it was achieved. *Id.* Thus, as the specification states, "[c]ommonly employed application and/or object thereof operating techniques lack a way for a system to learn [the] operation of an application and/or object thereof and enable autonomous operation of an application and/or object thereof." '585 patent at 1:45-55; '134 patent at 1:30-40.

62. As of the priority date of the Simulation Patents, the claimed features in the Simulation Patents, as a whole, were inventive and novel and were not well-understood, routine, or conventional. In general, the Simulation Patents are directed to a system, method and computer readable medium that allows an avatar or object (i.e., a virtual car) in a program to autonomously perform operations in response to an acquired image or object representation (e.g., a current circumstance surrounding the avatar or device in the application/simulation as captured

by the avatar's sensors, e.g., circumstance representations having object representations within the circumstance such as debris or people in the road) at least partially matching an image or object representation stored in a memory.

63. The '134 patent is specifically directed to innovations including correlating object representations with instruction sets for operating a first avatar of an application,[18] obtaining a second one or more object representations,[19] looking for a match between the second object representations and the first object representations,[20] and in response to finding a match causing a second avatar of the application to perform operations defined by the instruction set corresponding to the matched object representation.[21] For example, if a second avatar detects an object representation (e.g., objects such as virtual debris or virtual people in the road) and the system has a similar object representation that matches with the detected object, then the second avatar performs an instruction set (e.g., braking).[22] The corresponding claimed features, as a combination, are inventive and novel and were not well-understood, routine or conventional as of the priority date of the '134 patent.

[18] '134 patent at cl. 1 ("a first correlation including a first one or more object representations correlated with a first one or more instruction sets for operating a first avatar of an application").
[19] '134 patent at cl. 1 ("generating or receiving a second one or more object representations").
[20] '134 patent at cl. 1 ("determining the first one or more instruction sets for operating the first avatar of the application based on at least partial match between the second one or more object representations and the first one or more object representations").
[21] '134 patent at cl. 1 ("at least in response to the determining, causing … a second avatar of the application to perform one or more operations defined by the first one or more instruction sets for operating the first avatar of the application at least by executing the first one or more instruction sets for operating the first avatar of the application.")
[22] *Id.*

64. The ’585 patent is specifically directed to innovations including correlating digital pictures with instruction sets for operating a first object of an application,[23] obtaining a second one or more digital pictures,[24] searching for a match between the second digital pictures and the first digital pictures,[25] and in response to finding a match causing a second object of the application to perform operations defined by the instruction set corresponding to the matched digital picture.[26] For example, if a second object detects a digital picture (e.g., picture of virtual debris or virtual people in the road) and the system has a similar digital picture representation that matches with the detected picture, then the second object performs an instruction set (e.g., braking). The corresponding claimed features, as a combination, are inventive and novel and were not well-understood, routine or conventional as of the priority date of the ’585 patent.

65. Referring to Figure 35 of the ’585 patent, for example, object 180b (e.g., a vehicle) includes, in its knowledgebase, associated digital pictures 525 of the objects surrounding in a 3D virtual world 18b. ’585 patent at 166:38-167:67; Fig. 35; *see also* ’134 patent at 163:52-166:46; Fig. 36. If the system detects a match with a previously learned digital picture 525, the object 180b performs autonomous operation using previously learned instructions 526 correlated

[23] ’585 patent at cl. 1 (“one or more memories that store at least a first one or more digital pictures correlated with a first one or more instruction sets for operating a first object of a first application program”)
[24] ’585 patent at cl. 1 (“receiving or generating a new one or more digital pictures that depict at least a portion of a surrounding of: the first object of the first application program, a second object of the first application program, or a first object of a second application program”)
[25] ’585 patent at cl. 1 (“determining the first one or more instruction sets for operating the first object of the first application program based on at least partial match between the new one or more digital pictures and the first one or more digital pictures”)
[26] ’585 Patent at cl. 1 (“at least in response to the determining, executing the first one or more instruction sets for operating the first object of the first application program, wherein the first object of the first application program, the second object of the first application program, or the first object of the second application program autonomously performs one or more operations defined by the first one or more instruction sets for operating the first object of the first application program.”)

with the previously learned digital picture. '585 patent at 166:38-167:67; Fig. 35; *see also* '134 patent at 163:52-166:46; Fig. 36. In my opinion, the corresponding claimed features were not well-understood, routine or conventional as of the priority date of the Simulation Patents.

66. Given that the memory stores a first correlation (picture or object representation correlated with instructions learned by at least partially operating the first device) acquired by a first avatar, when a second avatar, for example, encounters a partially matching picture or object representation, the second avatar can autonomously perform an operation defined by the previously learned instruction that is correlated with the picture or object representation from the first avatar. The ability to cause one avatar to autonomously perform instruction(s) based on comparing a picture or object representation encountered by that device with a picture or object representation encountered by another or the same device was not known or done in the prior art.

67. The above-described claimed inventions provided a solution to this problem. By allowing one avatar's response (e.g., driver's response when driving a vehicle) to a circumstance to train other avatars (e.g., vehicles in a simulation) that encounter similar circumstances, the claimed knowledge base, together with the claimed anticipating and executing, allows a group of devices (e.g., a fleet of vehicles) to continuously and dynamically learn to respond autonomously to new and unforeseen circumstances, which occur in the simulation. Over time, nearly every circumstance can be accounted for and subsequently applied autonomously by all devices (e.g., the fleet of vehicles). The claimed features thus provide a specific and improved way for an avatar—and by proxy a real life vehicle—to respond autonomously to detected circumstances.

68. With the innovations in the Autonomous Vehicle Simulation Patents, autonomous device operation using a knowledgebase (e.g., a neural network that includes, for example, a combination of object recognition and correlated previously learned instructions) that is trained

by a fleet of vehicles became possible. *See, e.g.*, '134 Patent at 103:8-104:64; '585 Patent at 105:19-107:4. The corresponding claimed features were not well-understood, routine or conventional as of the priority date of the Simulation Patents. Moreover, the claimed features in the Simulation Patents cannot be performed as mental steps by a human, nor do they represent the application of a generic computer to any well-known method of organizing human behavior.

69. The claims of the Autonomous Vehicle Simulation Patents are directed to non-abstract ideas in that they provide technical solutions to at least the technical problems described above. For instance, claim 1 of each Simulation Patents, as a whole, is inventive and novel, as are at least the above-identified claim limitations. As of the priority dates of the Simulation Patents, the concept of causing a virtual device to perform autonomous operation based on: (i) pictures/representations of that device's circumstances and (ii) pictures/representations and instructions learned from that device or another device was not well-understood, routine, or conventional. These features provide a vast improvement over the prior art.

70. The claimed features unlocked the next level of autonomous driving. While fleet learning from real-world pictures and object representations can, in general, work, there were still inhibiting limitations such as scale and uniqueness. Regarding scale, the fleet is limited in its learning ability by the number of autonomous vehicles on the road that are conveying data back into the system. Similarly, regarding uniqueness, the fleet is limited in what it can learn based on the monitored autonomous vehicles experiences. The Simulation Patents address these issues by taking the concrete ideas found in the Object Representation and Digital Picture Patents and importing them into proper simulations. As discussed in the prosecution of both Simulation Patents, this was a completely novel idea as the prior art does not teach the details of object representations, avatars, determining instruction sets, and causing an avatar to perform

operations as recited in the claims. By allowing the entire fleet to train the system, as discussed earlier, and allowing appropriate simulations of driving reactions and situations including those situations that may represent improbable scenarios and edge cases, much more precise and appropriate reactions to driving circumstances became possible. This is because necessary but less probable or seldom occurring scenarios can be distilled into a set of circumstances/pictures and corresponding instructions that can be efficiently performed autonomously.

71. The claims of the Simulation Patents recite one or more inventive concepts rooted in computerized technology that overcome technical problems in that field. A person of ordinary skill in the art reading the Simulation Patents and their claims would understand that the Simulation Patents' disclosures and claims are drawn to solving specific technical problems arising in simulating artificially intelligent and autonomous devices and systems. Accordingly, each claim of the Simulation Patents recites a combination of elements sufficient to ensure that the claim in practice amounts to significantly more than a patent claiming an abstract concept. Further, the claimed improvements over the prior art are concrete and improve the capabilities of existing autonomous and AI simulation systems.

72. A person of ordinary skill in the art reviewing the specification of the Simulation Patents would understand that the inventor had possession of the claimed subject matter and would know how to practice the claimed invention without undue experimentation.

VII. CONCLUSION

73. I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct.

Executed on November 7, 2022.

By:________________________________

Eli Saber, Ph.D.

APPENDIX A

Prof. Eli Saber

Mobile: (585) 727-3126, **Email:** esaber228@gmail.com, **HTTP:** http://people.rit.edu/esseee

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EDUCATION

Ph.D., Electrical Engineering, University of Rochester, Rochester, New York (March 1996)
Concentration: Signal/Image/Video Processing, Pattern Recognition, and Computer Vision.
Dissertation: Automatic image annotation and query-by-example using color, shape and texture information.

M.S., Electrical Engineering, University of Rochester, Rochester, New York (May 1992)
Concentration: Signal/Image/Video Processing, Pattern Recognition, Computer Vision, Communications.

B.S., Electrical and Computer Engineering, Summa Cum Laude, State University of New York at Buffalo, Buffalo, New York (May 1988).
Concentration: Computers, Microprocessors, Communications, Instrumentation.

A.S., Engineering Science, Mohawk Valley Community College, Utica, New York (May 1986)

CAREER MAJOR HIGHLIGHTS

❖ **Academic Experience:**
- **Teaching:** Taught/continue to teach undergraduate and graduate courses in the signal/image/video processing, computer vision, controls and communications focus areas with excellent feedback from students from 1996 to Present. Founded new coursework in Digital Video Processing and Pattern Recognition.
- **Research:** Conducted research on multiple acquired government and industry grants in the areas of: 1) image/video processing for multimedia, military and biomedical applications, 2) deep learning/artificial intelligence for object detection and tracking purposes, 3) three-dimensional scene reconstruction for remote sensing, and 4) color image processing for printing and multimedia applications. Graduated several PhD and MS students. Currently co-advising 2 PhD students.
- **External Funding:** Acquired external funding as PI in excess of $3.5 Million and as PI/Co-PI in excess of $5 Million over the period of September 2004 to present from government agencies and industry partners.
- **Publications:** 1 Book, 2 Special Issues, 38 Journal, 100 Conference and 11 Patents/Patent Publications.
- **Service:** Served/chaired several department, college and university level committees. Chaired the Graduate Program at the EE department for a period of five years. Served on the academic senate for a period of 9 years and on the Academic Senate Executive Committee for a period of 3 years.

❖ **Industrial Experience:** Worked for Xerox Corporation from 1988 until 2004 in a variety of engineering, managerial and scientific positions ending as Product Development Scientist and Manager.

❖ **Consulting/Litigation Experience:** Served as an expert in several patent and non-patent cases representing numerous companies. Provided declarations in support of multiple Inter Partes Reviews (IPR), expert opinions and reports with regards to validity/invalidity, infringement/non-infringement and domestic industry, tutorial at Markman hearing, multiple depositions, and testimony in court proceedings.

❖ **Professional Activities:** Served on several IEEE and SPIE conferences in various chair positions including Finance, Tutorials, Plenaries and Technical Program. Served as general chair for two conferences.

❖ **Honors & Awards:** RIT Trustees Award (2012), KGCOE Scholarship Award (2012), EME Gleason Professor (2011-2013), and PI Millionaire (2011).

RESEARCH INTERESTS

- Image and Video Processing for Multimedia, Military & Biomedical Applications.
- Computer Vision and Three-Dimensional Scene Reconstruction.
- Color Image Processing for Printing and Multimedia Applications.

ACADEMIC EXPERIENCE

Professor (Associate 2004 – 2010, Full 2010 – Present), Department of Electrical and Microelectronic Engineering (EME), Kate Gleason College of Engineering (KGCOE), Rochester Institute of Technology.
Extended Faculty (2004 – Present), Center for Imaging Science (CIS), Rochester Institute of Technology.
Director of the Image, Video and Computer Vision Laboratory (2004 – Present)
Graduate Program Director (2010 – 2014)

- **Teaching:** Responsible for teaching undergraduate & graduate courses in Digital Signal Processing, Digital Image Processing, Digital Video Processing, Engineering Analysis, Advanced Engineering Mathematics, Random Signal & Noise, Pattern Recognition, Communication Systems, Digital Data Communications, Computer Vision, Modern Control Theory, Linear Systems, and Matrix Methods. Typically teaching two courses per semester as required by department. Have taught three per semester on occasion to fulfill department needs.
- **Research:** Director of the Image, Video and Computer Vision Laboratory. Currently co-advising 2 PhD and 2 MS students on deep learning/machine learning/artificial intelligence applications for object detection and tracking. Advised several PhD and MS students in image/video segmentation, hierarchical image decomposition, video mosaicking/3-dimensional scene reconstruction, image/video understanding, object tracking/recognition. All students are/were funded under various government or corporate grants.
- **Funding:** Acquired funding as PI in excess of $3.5 Million and as PI/Co-PI in excess of $5 Million over the period of September 2004 – Present from various government agencies and industrial partners.
- **Service (Department, College and University):**
  - Advised/currently advising several undergraduate and graduate students on curriculum issues.
  - Member of the Academic Senate Resource Allocation and Budget Committee, the University Compensation Committee and of the Kate Gleason College of Engineering Promotion Committee.
  - Former Member (KGCOE representative) of the Academic Senate (2007 – 2013 and 2014-2017) and of the Academic Senate Executive Committee (2009-2010, 2016-2017).
  - Served as Chair of the RIT Vision 2025 committee per request from RIT President Dr William Destler. Committee was commissioned, over the summer of 2009, to review 80+ ideas submitted from all colleges and provide a recommendation to upper administration.
  - Former Member and Chair of KCGOE graduate committee.
  - Former Member of Graduate Council.
  - Served on several committees for curriculum development, recognition, and faculty search.
- **Professional Activities:**
  - Senior member of the Institute of Electrical and Electronic Engineers (IEEE) society.
  - Former Member of the IEEE Industry Technical Committee on DSP.
  - Former Member of the IEEE Image and Multidimensional Digital Signal Processing (IMDSP) technical Committee.
  - Former Area Editor for the Journal of Electronic Imaging.
  - Former member of the Imaging Science and technology (IS&T) society.
  - International Conference on Image Processing (ICIP) 2002 Finance Chair, ICIP 2007 and ICIP 2009 Tutorial Chair, ICIP 2012 General Chair, ICASSP 2017 Technical Program Chair, ICIP 2021 Plenary Chair.
  - Co-founder and General Chair of the Video Surveillance and Transportation Imaging Conference within the Electronic Imaging Symposium.
- **Honors and Awards:**
  - Awarded the Prestigious Trustees Scholarship award – the highest award at RIT with regards to research recognition
  - Elected in 2011 as PI Millionaire.

- ❖ Awarded the EME Gleason Professor for 3 years (2011-2013).
- ❖ Elected as the Kate Gleason College of Engineering Scholarship award winner.

Adjunct Faculty Member, Dept. of Electrical & Computer Engineering, University of Rochester. (09/96-07/04)

- ❖ Taught undergraduate & graduate courses in Digital Signal Processing, Digital Image Processing, Pattern Recognition/Advanced Image Processing, Detection/Estimation Theory, and Analog & Digital Communications.
- ❖ Advised and graduated 1 Ph.D. student in the areas of "Image Understanding" and "Database Content Indexing".
- ❖ Co-advised 1 Ph.D. student in the areas of "Watermarking".
- ❖ Advised and graduated 1 MS student in the area of "Color Rendering" and "Printer Characterization".
- ❖ Served as a committee member on several doctoral dissertations.
- ❖ Served on PhD qualifying examinations for the Signal Processing and Communications Concentration.
- ❖ Sought and captured funding from the National Science Foundation for the development of an intelligent image database system. Proposal funded for 4 years under NSF Grant IIS – 9820721
- ❖ Sought and captured industrial funding from Xerox Corporation for Printer Color Characterization & Digital Front End Object Oriented Rendering.

Adjunct Faculty Member, Dept. of Electrical Engineering, Rochester Institute of Technology. (03/98-07/04)

- ❖ Taught undergraduate and graduate courses in Pattern Recognition, Digital Video Processing, Random Signal & Noise, Image and Video Compression, and Communications.
- ❖ Advised and graduated a master student in the area of "Texture Classification".

INDUSTRIAL EXPERIENCE

Product Development Scientist & Manager, Print Engine Development Unit, Xerox Corporation. (10/98-08/04)
Major responsibilities included:

- ❖ Lead the Image Science, Analysis and Evaluation area (12-15 direct reports and ~$2 Million budget).
- ❖ Lead the development of highlight color specifications for the Sorrento print engine.
- ❖ Lead the development of color characterization algorithms for the iGen3 print engine.
- ❖ Lead the image quality integration of two color front end for the iGen3 Product.
- ❖ Lead the development of ROS and LED based imaging systems and image path architectures for upcoming highlight & full color products.
- ❖ Lead the development of xerographic hardware/algorithms & imaging systems for the DP92C highlight color product. (Product launched 9/30/99 and follow-on launched 4/20/00)
- ❖ Lead the research and development of image quality metrics for various product platforms and their dissemination throughout the Print Engine Development Unit and Xerox Corporation.
- ❖ Collaborate with the Department of Electrical & Computer Engineering (Univ. of Rochester) & the Center for Electronic Imaging Systems.

Advanced Development Scientist and Manager, Print Cartridge Delivery Unit, Xerox Corporation. (2/97 – 9/98)
Major responsibilities included:

- ❖ Establish the Advanced Design Laboratory (an imaging/xerographics lab) and provide technical and managerial leadership for the Electrical, Imaging and Xerographics Dept.
- ❖ Perform image processing and xerographic hardware/software design and development for low/mid volume color copiers and printers for current and future programs.
- ❖ Perform technology development, modeling, and product design for upcoming Xerox color products, specifically image on paper and image on belt products..
- ❖ Lead the development of the xerographic module for a color intermediate belt transfer product with direct technical and management responsibilities.
- ❖ Collaborate with the Department of Electrical & Computer Engineering (Univ. of Rochester) & the Center for Electronic Imaging Systems.

Research and Development Scientist, Production Systems Group, Xerox Corporation. (1/96-1/97)

Major responsibilities included:

- ❖ Lead the design and development of color characterization/management and image quality algorithms and specifications for digital front ends destined to drive high quality, high speed color print engines.
- ❖ Integrate color management & image processing algorithms into the Raster Image Processing module.
- ❖ Participate in the design and development of a high speed raster image processing architecture.
- ❖ Benchmark developed algorithms against existing products & systems both internally and externally.
- ❖ Collaborate with the Department of Electrical & Computer Engineering of the University of Rochester and the Center for Electronic Imaging Systems.

Research and Development Engineer, Corporate Research, Xerox Corporation (8/93-12/95) & Department of Electrical & Computer Engineering, University of Rochester. (1/95-12/95). Major responsibilities included:

- ❖ Design and develop query by image content and query by example image annotation algorithms utilizing color, shape, texture and motion cues. System is able to perform query by keywords, color, shape, texture, and/or a combination of the above cues.
- ❖ Design and develop intelligent image segmentation algorithms. These algorithms are currently utilized in the query by image content and query by example systems described above.
- ❖ Design and develop face detection and facial feature extraction approaches.
- ❖ Design and develop color characterization/calibration and image quality algorithms for Digital Front Ends aimed at driving high speed / high quality print engines.

(Note: Image annotation/content analysis research was done in conjunction with the Department of Electrical & Computer Engineering and Center for Electronic Imaging Systems leading to the Ph.D.)

Electronic, Computer and Instrumentation Engineer, New Toner/Developer Facility Engineering, Xerox Corporation. (6/88-7/93). Major responsibilities included:

- ❖ Provide design, development, installation, startup, and training for multiple toner production facilities.
- ❖ Provide development and implementation of control system database, software and displays for several systems.
- ❖ Evaluate vendor supplied electrical specifications and drawings.
- ❖ Manage and coordinate the efforts of technicians, electrical support, construction crew, and industrial workforce during the design, construction, startup, and implementation phases.
- ❖ Supervise and complete a number of upgrade projects for toner & photoreceptor production including software development, preparation of electrical design, procurement of necessary equipment and parts, supervision of technicians, contractors and industrial workforce, and scheduling of construction.

During this time, I gained extensive experience in the following systems: Fisher distributive control, unit operation controller, Provue console, Acrison material handling, Werner and Pfleiderer extrusion, Alpine air grinding, Majac/Micropul centrifugal classifiers, dry/wet material screening, Waeschle and others bulk powder storage and pneumatic convey, Ingersoll Rand and Joy compressed air equipment, Statistical process control.

CONSULTING EXPERIENCE

Expert on Legal Cases: Served as expert in multiple patent cases representing various companies such as Facetec, Autonomous Devices, Lyft, Genetec, Interactive Digital Solutions, Hisense, Perfect Corporation, Corephotonics, Wells Fargo, Netflix, Blackberry, 3Shape, Nikon, Hewlett-Packard, Qomo Hitevission, Sony, and Canon.. Provided: 1) declarations in support of multiple Inter Partes Reviews (IPR); 2) expert opinions and reports with regards to validity/invalidity, infringement/non-infringement and domestic industry; 3) tutorial at Markman hearing and 4) testimony in multiple court proceedings.

Summary of Experience:

- IPR/Declarations: Provided declarations in support of 19 IPR proceedings.
- Depositions: Provided 11 Depositions.
- Court Testimony: Testified in International Trade Commission Court in Sept. 2018 and Oct. 2019.
- Expert Opinions: Provided multiple expert opinions and reports in support of validity/invalidity, infringement/non-infringement, domestic industry and rebuttals.

- Claim Construction: Provided reports in support of claim construction.
- Hearings: Attended one Markman hearing and provided a brief technology tutorial.

Industrial Training: Developed and conducted industrial training at Xerox Corporation for engineering personnel over three separate summer periods in the areas of signal and image processing, color engineering, and control systems with a distinct focus on digital front ends and print engines. I have also provided pattern recognition/shape matching expertise for Leica corporation.

BOOKS

1. S. Dianat and E. Saber, "Advanced Linear Algebra for Engineers with MATLAB", CRC press, February 2009.

SPECIAL ISSUES

1. H. J. Trussell, E. Saber and M. Vrhel, "Color Image Processing", IEEE SP magazine, January 2005.
2. R. Loce and E. Saber, "Video Surveillance and Transportation Imaging", Journal of Electronic Imaging, 22(4), Dec. 2013

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1. M. Sharma, M. Dhararaj, S. Karnam, D. Chachlakis, R. Ptucha, P. Markopoulos and E. Saber, "YOLOrs: Object Detection in Multimodal Remote Sensing Imagery", IEEE Journal of Selected Topics in Applied Observations and Remote Sensing, Vol. 14, 2021.
2. S. Piramanayagam, E. Saber, and N. Cahill, "Gradient Driven Unsupervised Video Segmentation using Deep Learning Techniques", Journal of Electronic Imaging, 29 (1), 013019, 2020
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1. D. Cherry, R. Jessome, R. Maggard, D. Siddall, Y. Raja and E. Saber, "Part Replacement Predictions using Convolutional Neural Networks", under review.
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3. P. Lee, E. Saber, O. de Lima, D. Day, P. Bauer, M. Shaw, R. S. Twede, S. Janakiraman, B. Sorensen. "Detecting Document Objects". # PCT/US2015/053762.
4. S. Vantaram, E. Saber, S. Dianat, M. Shaw and R. Bhaskar, "Methods for Adaptive and Progressive Gradient-Based Multi-resolution Color Image Segmentation and Systems Thereof", US 8515171B2.
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6. E. Saber, M. Nelson, M. Stauffer, D. Bohan and R. Kothari, "Correcting Artifacts on A Display", US Patent 9,620,082.
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8. E. Saber & R. Loce, "Corner Sharpening of Text and Line Art in a Super Resolution Anti-Aliasing Image Path", US Patent 7,536,052.
9. L. K Mestha, S. Bolte, E. Saber, and S. Updegraff, "Systems and Methods for Obtaining a Spatial Color Profile, and Calibrating a Marking System", US Patent Application Publication 2004/0136013, July 2004.
10. L. K. Mestha, E. Saber, "Systems and methods for sensing marking substrate area coverage using a spectrophotometer", US Patent 7,110,142 and European EP1309176A2.
11. D. Damji, A. Leon, P. Perez and E. Saber, "Processing system for replaceable modules in a digital printing apparatus", European Patent EP1079278B.
12. E. Saber, D. Damji, A. Leon, and P. Perez, "Remanufacturing system for replaceable modules in a digital printing apparatus", US Patent 6173128.

EXTERNAL FUNDING/FUNDED PROPOSALS

Proposals Funded while at RIT

- Acquired/continue to acquire funding with multiple grants from government agencies and corporate partners (Hewlett-Packard, Dataphysics, Lenel, Xerox) in excess of $3.5 Million as PI and in excess of $5 Million as PI/Co-PI (total Portfolio) since joining RIT. A complete statement listing the details of each grant can be provided upon request.

Proposals Funded prior to Joining RIT as an employee of Xerox Corporation and University of Rochester:

- A. M. Tekalp and E. Saber (co-PI), "An intelligent visual database system: Hierarchical content description and matching using integrated similarity metrics", funded for $243K for four years at the University of Rochester by the National Science Foundation under NSF Grant IIS – 9820721.

HONORS AND AWARDS

- Awarded the Prestigious Trustees Scholarship award – the highest award at RIT with regards to research recognition (2012)
- Elected as the Kate Gleason College of Engineering Scholarship award winner (2012).
- Elected as Electrical and Microelectronic Engineering Gleason Professor for 3 years Fall 2011 – Summer 2014.
- Elected as PI Millionaire by RIT Sponsored research organization.
- Winner of an M.S./Ph.D. scholarship for graduate study from Xerox Corporation.
- Winner of the quality recognition award from Xerox Corporation for outstanding performance.
- Core member of a toner/developer facility engineering project team recognized as ``The 1991 and 1993 team of the year" by the Delaware Valley Chapter of the Project Management Institute.
- Elected to the Electrical Engineering Honor Society, Eta Kappa Nu.
- Winner of Gibran Khalil Gibran Scholarship for outstanding academic achievements.
- Valedictorian of the Electrical and Computer Engineering Department at the University of Buffalo.
- Recipient of several prizes and awards from the University of Buffalo and the Mohawk Valley Comm. College for excellent academic achievements; and from Xerox Corporation for outstanding performance.

PROFESSIONAL ACTIVITIES

- Senior Member of the Institute of Electrical & Electronic Engineers.
- Member of the IEEE Signal Processing Society.
- Plenary Chair for ICIP 2021.
- Technical Program Chair for ICASSP 2017 in New Orleans.
- General Chair for ICIP 2012.
- Member of the IEEE Signal Processing society conference board for 3 year team starting January 2013.
- Tutorial chair for the International Conferences on Image Processing, ICIP 2007 and ICIP 2009.
- Special session chair on Color Image Processing for the European Signal Processing Conference, Sept. 2006.
- Finance Chair for the International Conference on Image Processing 2002 held in Rochester, NY.
- Former Area Editor for the Journal of Electronic Imaging.
- Guest Editor for the "Color Image Processing" issue of the Signal Processing Magazine.
- Associate Editor for the IEEE Transactions on Image Processing for five years. Term ended: April 2009.
- Former Associate Editor for the IEEE Signal Processing Magazine for DSP Applications Forum.
- Former Member of the IEEE Image & Multidimensional Digital Signal Processing Technical Committee.
- Former Member of IEEE Tech. Comm. on Industry DSP Technology in 2003 & 2004 & Chair for 2005, 2006.
- Technical program committee member for ICIP 2009 and prior ICIPs.

- Technical program committee member for ICASSP 2010 and prior ICASSPs.
- Session chair for several ICIP & ICASSP Conferences and Workshops.
- Chairman, vice-chairman, treasurer, and secretary of the IEEE Rochester Chapter of the signal processing society in 1998, 1997, 1996 and 1995 respectively.
- Reviewer for the IEEE Trans. on Image Processing, IEEE Trans. on Pattern Analysis and Machine Intelligence, Graphical Models and Image Processing, IEEE Trans. on Signal Processing, IEEE Signal Processing Letters, Color Research and Applications, Graphical Modeling and Image Understanding, Image and Vision Computing, Optical Engineering, Journal of Imaging Science and Technology, and the Journal of Electronic Imaging.
- Technical committee for Western New York Imaging Workshop in 1997 and 1999 and general chair in 1998.
- Co-Chair of the Xerox Electronic Image and Video Processing Technology Council.

References Available Upon Request

APPENDIX B

1. U.S. Patent Nos. 10,452,974; 11,238,344; 10,607,134; 11,113,585; 11,055,583; and 10,102,449.
2. File Histories Corresponding to U.S. Patent Nos. 10,452,974; 11,238,344; 10,607,134; 11,113,585; 11,055,583; and 10,102,449.
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4. U.S. 2016/0167226
5. Pomerleau, D.A. (1991) Efficient Training of Artificial Neural Networks for Autonomous Navigation. In Neural Computation 3:1 pp. 88-97
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